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Moll

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[54] **WELL INFORMATION TELEMETRY BY VARIATION OF MUD FLOW RATE**

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[73] Assignee: **Scientific Drilling International,** Houston, Tex.

[21] Appl. No.: **895,135**

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Related U.S. Application Data

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[51] **Int. Cl.**[4] **G01V 1/40**

[52] **U.S. Cl.** **367/83;** 175/48

[58] **Field of Search** 367/81–85; 175/40, 48; 181/102; 340/853; 73/151–155

[56] **References Cited**

U.S. PATENT DOCUMENTS

Re. 28,436	6/1975	Vitter, Jr. et al.	73/151
2,290,408	7/1942	Crites	175/48
3,455,401	7/1969	Taylor, Jr.	175/45
3,711,825	1/1973	Claycomb	367/83
3,813,656	5/1974	Fowler	367/85
3,908,453	9/1975	Jeter	367/81
3,958,217	5/1976	Spinnler	367/85
3,960,015	6/1976	Jett et al.	73/155
3,983,948	10/1976	Jeter	175/45
4,078,620	3/1978	Westlake et al.	175/48
4,188,624	2/1980	Hochaprung et al.	340/606
4,266,606	5/1981	Stone	73/151
4,303,994	1/1981	Tanguy	367/84
4,405,021	9/1983	Mumby	175/48
4,553,226	11/1985	Scherbatskoy	367/85

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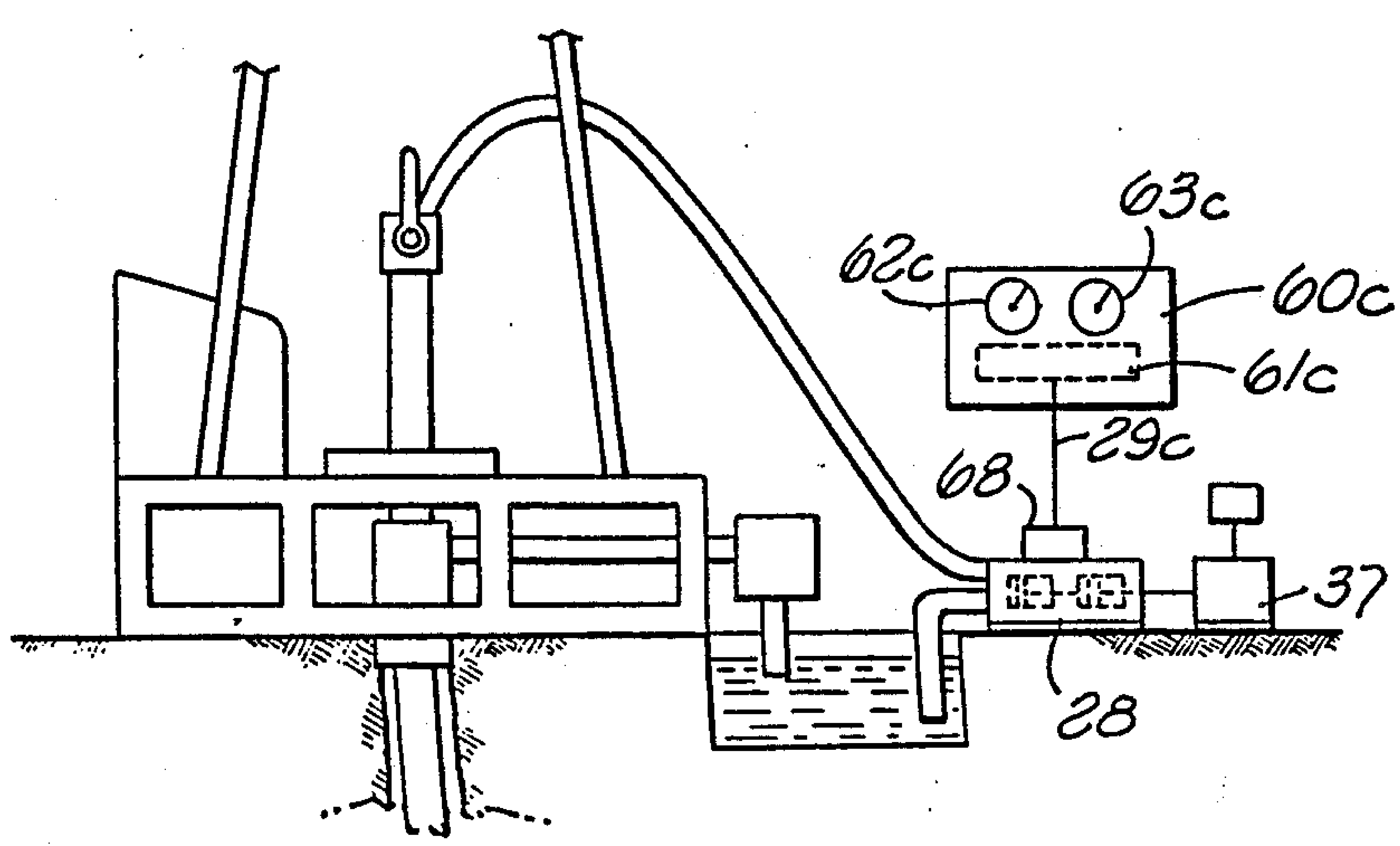
[57] **ABSTRACT**

Information is conveyed from downhole location within a well, by varying the rate of flow of drilling fluid at the downhole location in accordance with changes in a predetermined condition at that location, and then sensing variations in the rate of flow of the drilling fluid at the surface of the earth as an indication of the downhole information being transmitted. A read-out unit can be actuated in accordance with the information sensed at the surface of the earth to give a visual indication or other output representative of or dependent upon the downhole information.

16 Claims, 8 Drawing Figures



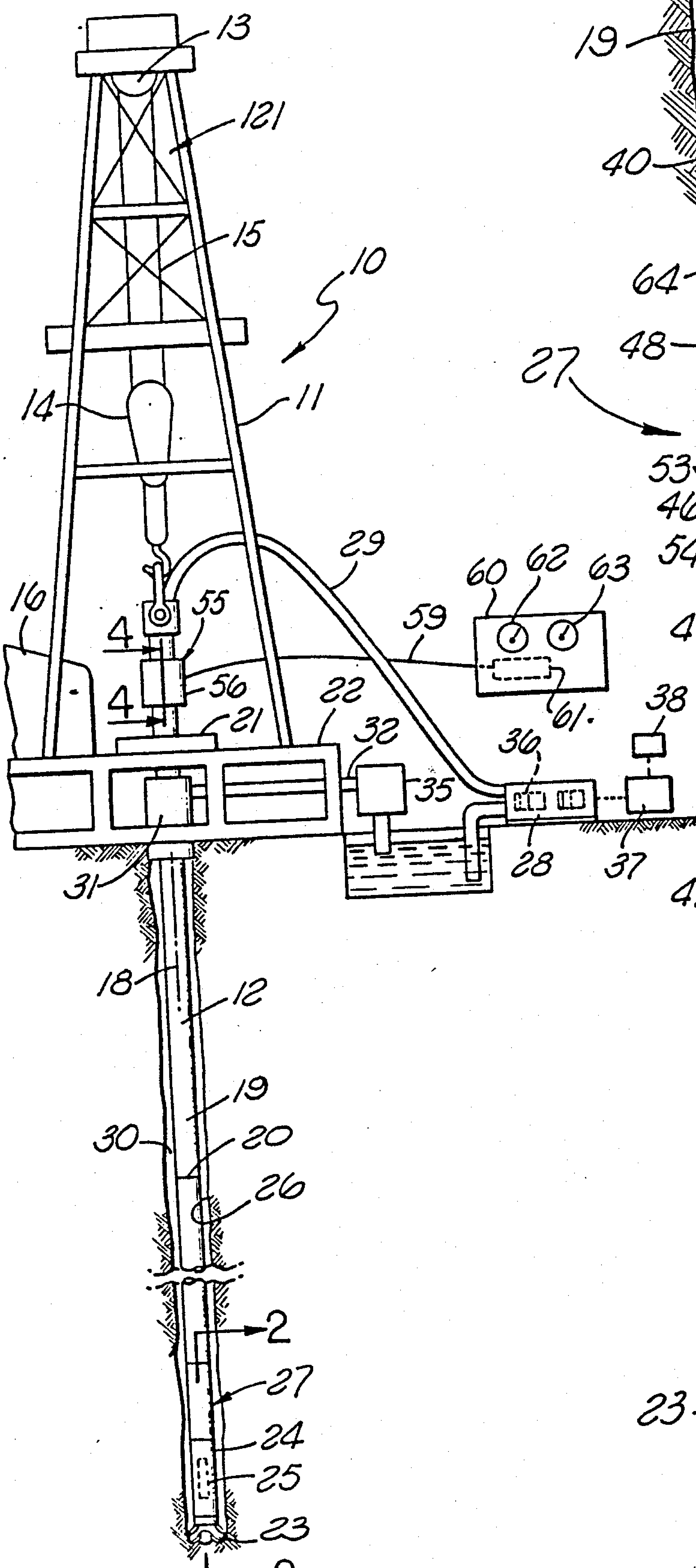

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FIG. 1

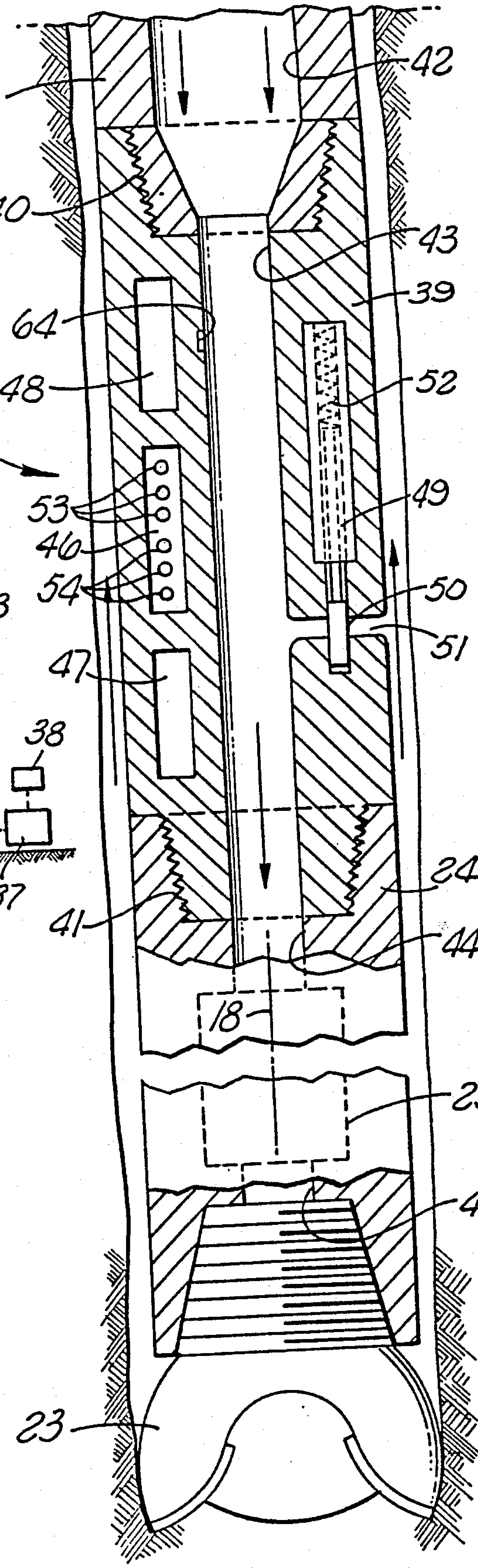
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FIG. 2

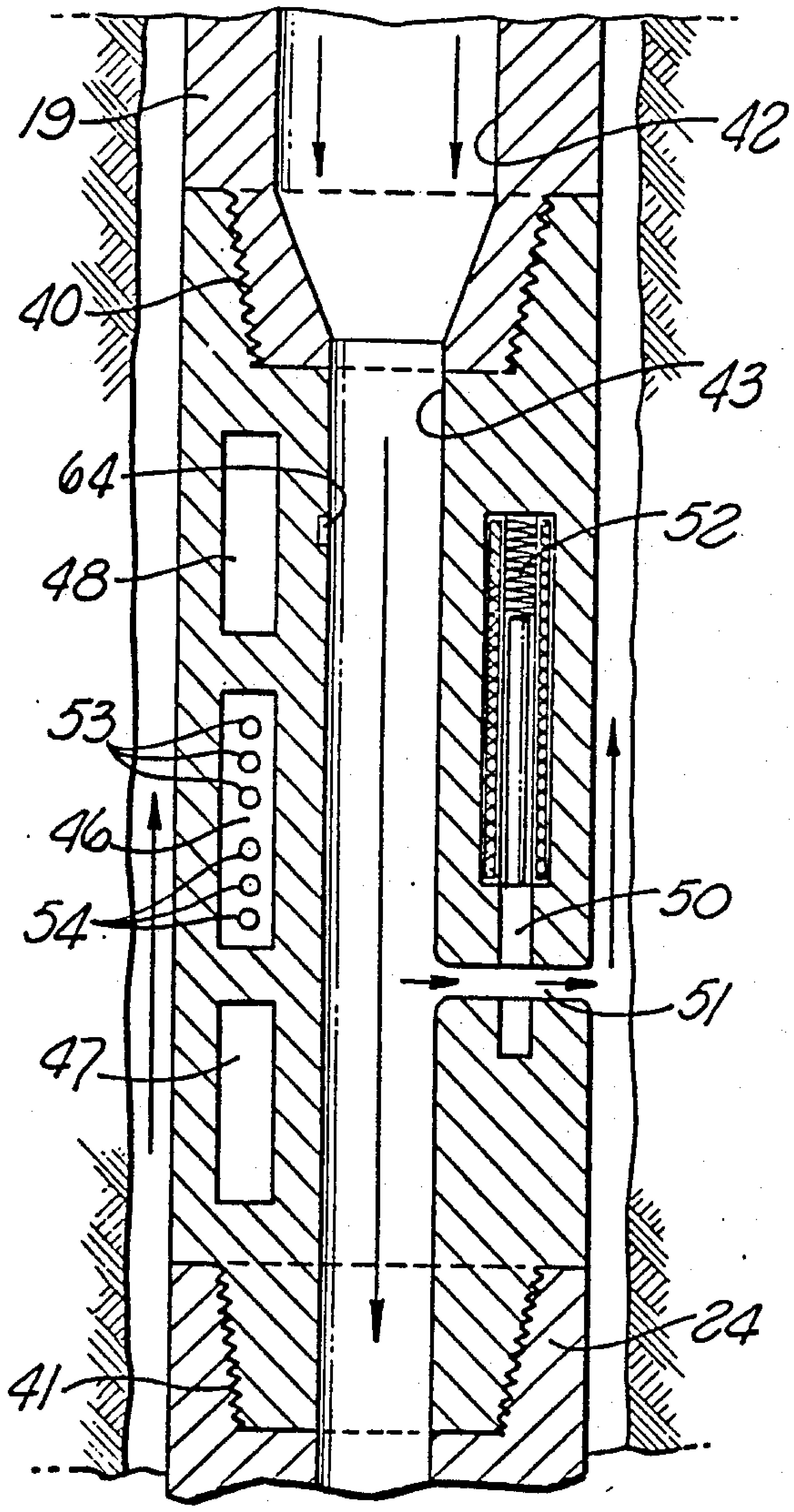

FIG. 3

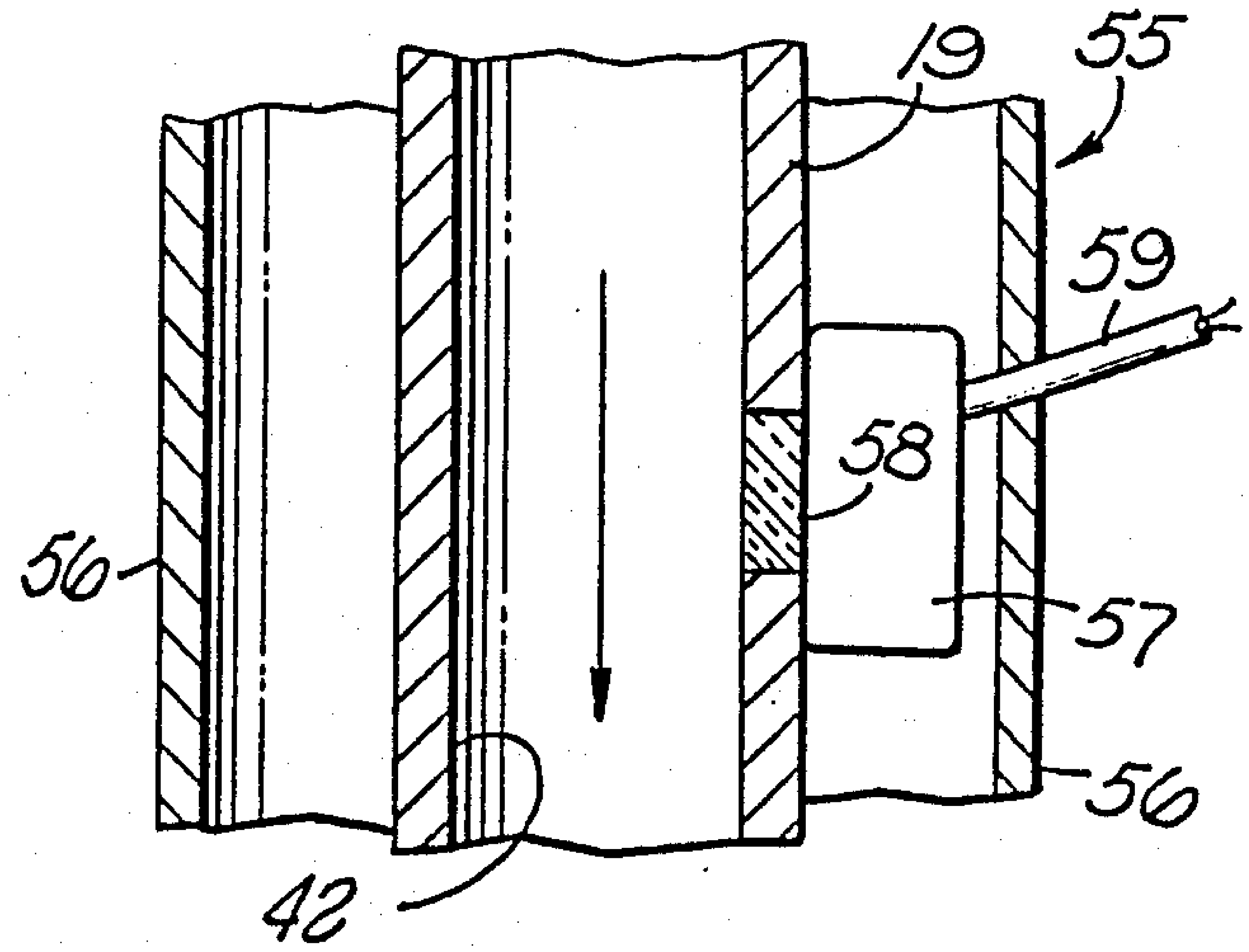

FIG. 4

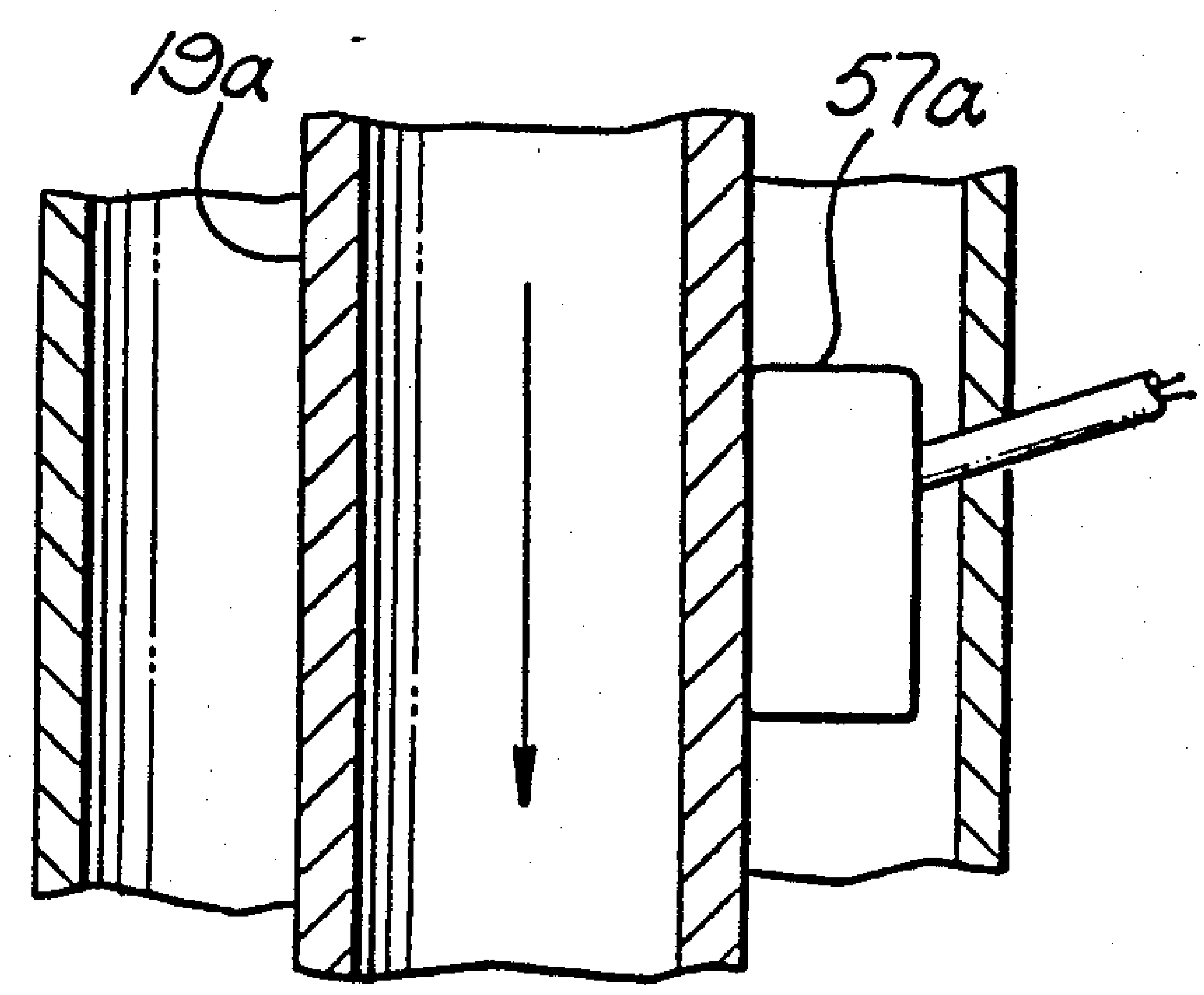

FIG. 5

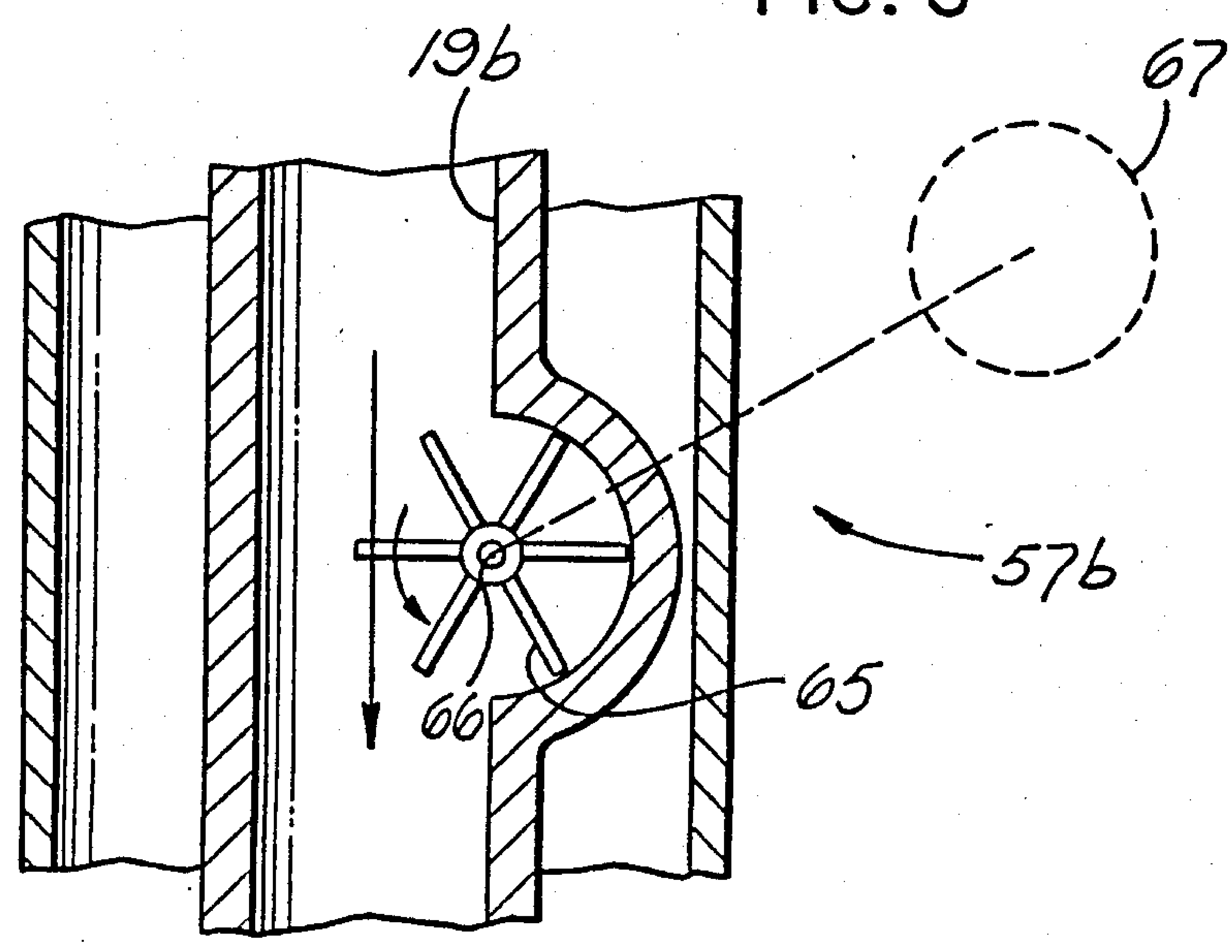

FIG. 6

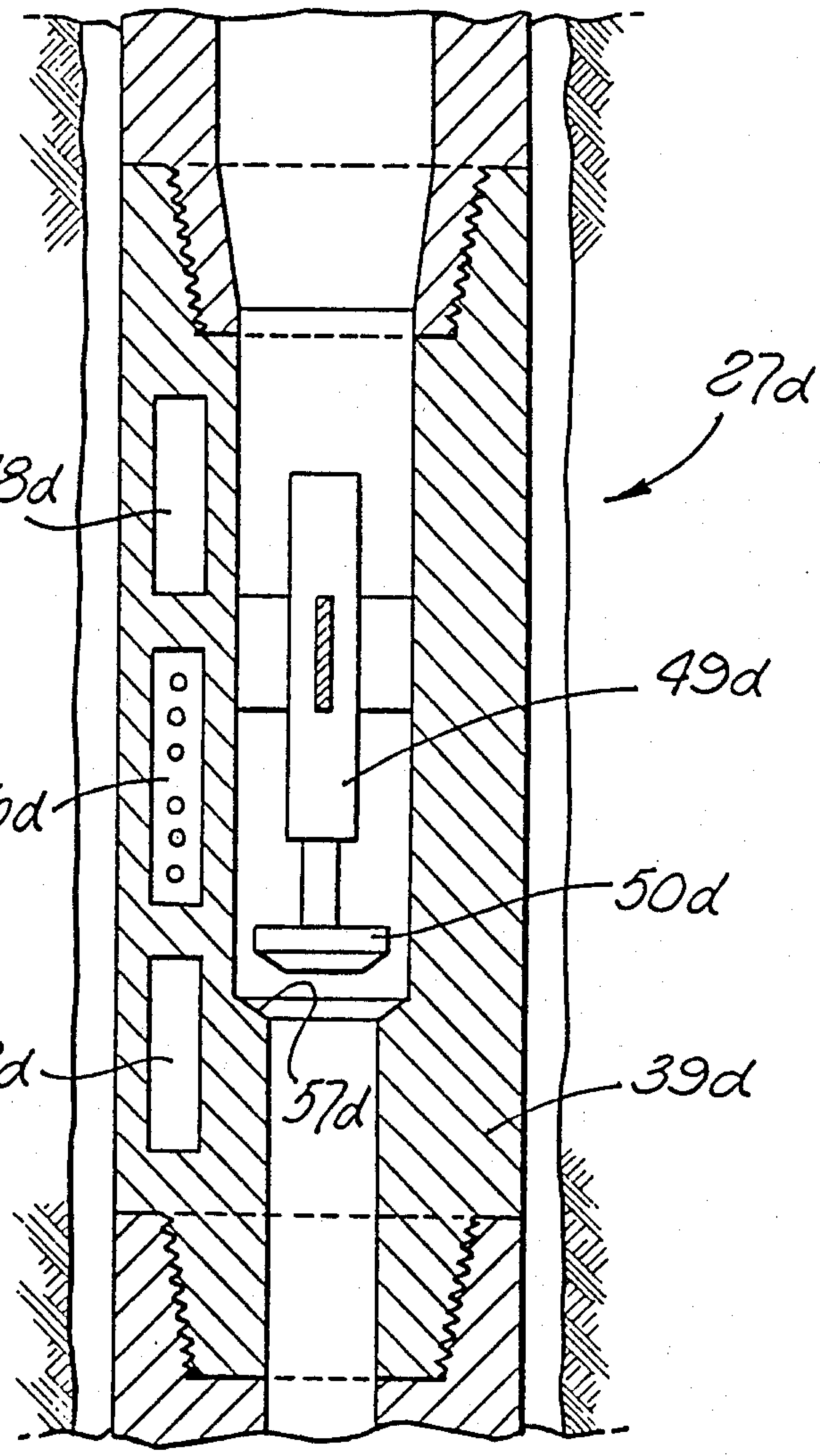

FIG. 8

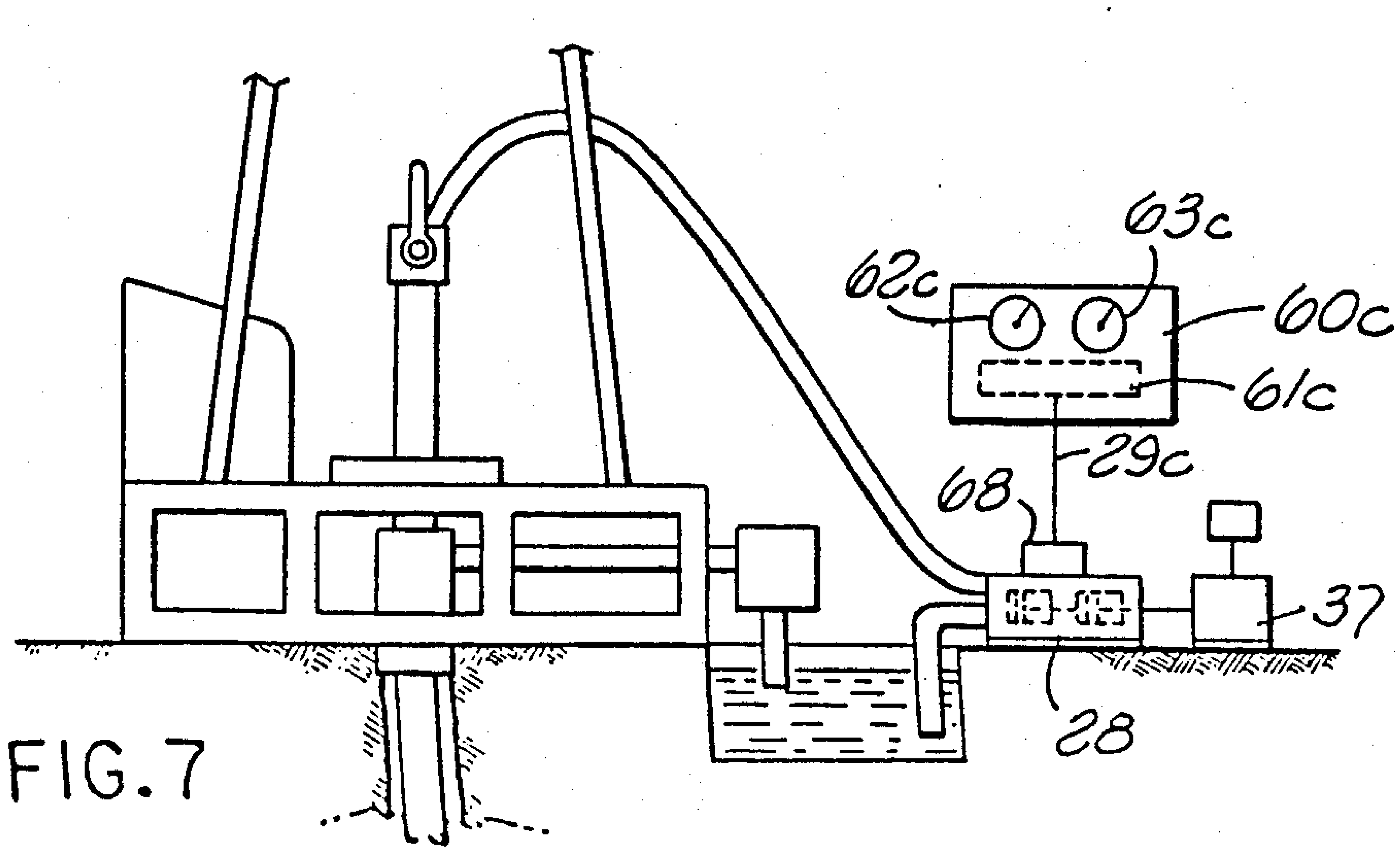

FIG. 7

WELL INFORMATION TELEMETRY BY VARIATION OF MUD FLOW RATE

This is a continuation of application Ser. No. 757,182, filed July 18, 1985.

BACKGROUND OF THE INVENTION

This invention relates to improved apparatus and methods for conveying information from a downhole location deep within a well to the surface of the earth, in order to apprise a driller of one or more conditions which exist in the well.

During drilling of a well, it is essential in most instances that frequently updated information be obtained as to the conditions which exist at the bottom of the well. For example, the inclination of the lower portion of the drill string and the direction of that inclination are often of critical importance, particularly in directional drilling, in order to assure that the hole is drilled along an intended path. Similarly, it may be desirable to convey to the surface of the earth information relative to temperature and pressure conditions at the bottom of the hole, the weight which is applied to the bit at a particular instant, and other parameters important to ulimate completion of a satisfactory drilling operation.

In the past, much of this downhole information has been obtained by instruments which have been lowered into the drill string on a wire line, and which after obtaining the information are withdrawn upwardly from the drill string before the drilling operation can be continued. In order to avoid the necessity for lowering an instrument into the drill string on a wire line, attemps have been made to devise systems for conveying information from a downhole location to the surface of the earth by telemetry not requiring a wire line. Some of these systems contemplate development of pressure pulses in the drilling fluid, with sensors being employed at the surface of the earth for responding to those pressure pulses and producing an output therefrom representing the downhole information. In some instances, a pressure pulse is produced by momentarily bypassing some of the circulating fluid at a location above the bit from the interior of the drill string to its exterior. In other types of equipment, a pressure pulse has been caused by closing a valve through which drilling fluid flows downwardly within the drill string and toward the bit. In either case, the surface equipment responds to the momentary increase or decrease in pressure resulting from actuation of a valve at the downhole location.

SUMMARY OF THE INVENTION

The present invention provides a different and improved arrangement for transmitting information from a downhole location to the surface of the earth without the use of wire lines. Apparatus and methods embodying the present invention can be employed to convey information to the surface of the earth either with the drilling bit stationary or while it is turning during an actual drilling operation. In the latter case, corrections can be made in the direction of drilling or in other drilling conditions while the bit turns and while completely updated information is being continuously supplied to an operator at the surface of the earth, indicating precisely what results are attained by any changes made in the drilling equipment. The apparatus which accomplishes this result, however, may be very simple structurally, rugged in construction, and adapted to function in a very straightforward manner for reliable trouble free operation over long periods of time.

The equipment of the invention employs apparatus at the surface of the earth which acts to sense variations in the rate of flow of the drilling fluid, and then controls a readout unit to produce an output dependent upon such variations in flow rate. The downhole equipment alters the flow rate of the circulation fluid in a pattern representing information which is to be conveyed to the surface, and the surface equipment in responding to the flow rate variations acts to receive that information. The downhole appartus for controllably altering the drilling fluid flow rate may include a valve or valves acting to bypass the fluid from the interior to the exterior of the drill string or acting to vary the rate of fluid flow downwardly through the string.

The flow rate sensor at the surface of the earth may be of any known type, such as a mechanical, electronic or optical sensor. Alternatively, response to the change in rate of fluid flow at the surface may be attained by monitoring changes in the rate of operation of the mud pump which delivers drilling fluid to the upper end of the drill string. For example, the rate of operation of the mud pump may be monitored acoustically, with the derived acoustical signals being employed to control a readout unit.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features and objects of the invention will be better understood from the following detailed description of the typical embodiments illustrated in the accompanying drawings, in which:

FIG. **1** is a diagrammatic representation of a well drilling rig provided with telemetry apparatus embodying the present invention;

FIG. **2** is an enlarged vertical section taken on line **2—2** of FIG. **1**, and showing somewhat schematically the downhole portion of the apparatus of FIG. **1**, with a drilling fluid bypassing valve in its closed condition;

FIG. **3** is a view similar to FIG. **2**, but showing the valve in its open condition;

FIG. **4** is an enlarged fragmentary vertical section taken on line **4—4** of FIG. **1**, and showing the surface flow sensing equipment utilizing an optical flow meter arrangement;

FIG. **5** is a view similar to FIG. **4** but showing schematically an electronic or magnetic flow meter arrangement;

FIG. **6** is a view similar to FIG. **4**, but showing use of a mechanical flow meter;

FIG. **7** represents fragmentarily an acoustical flow sensing system; and

FIG. **8** shows a variational arranagement in which the valve regulates flow of fluid downwardly through the drill string rather than between its interior and exterior.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

There is illustrated diagrammatically at **10** in FIG. **1** a well drilling rig which is in most respects conventional, and includes the usual upwardly projecting derrick or mast **11** from which a drill string **12** is suspended by a block and tackle assembly **121** including a crown block **13** and a traveling block **14** suspended from the crown block by a line **15**. The drawworks **16** actuates line **15** to move the traveling block and drill string upwardly and downwardly along a vertical axis **18**. The string is formed of a series of tubular pin sections **19** threadedly interconnected in end to end relation at joints **20**. It is contemplated that for purposes of the present invention, the apparatus may either be of a type in which the entire string is rotated by a rotary table **21** mounted on the rig floor **22**, or of a type in which the string is stationary and only the bit **23** at its lower end rotates. FIG. **1** typically illustrates the latter arrangement, with the lowermost section **24** of the drill string containing a motor **25** of known type adapted to be driven by the pressure of drilling fluid circulated downwardly through the drill string to turn bit **23** about axis **18** for progressively drilling well **26** as the string is lowered relative to the rig framework structure. Connected into the string above the bottom motor section **24** is an instrument section **27** which develops and transmits the information to be conveyed to the surface of the earth.

The drilling fluid or mud is delivered under pressure by a pump **28** through a flexible hose **29** to the upper end of the drill string **19**, and flows downwardly through that string to bit **23**, at which the fluid is discharged through restricted passages in the bit to the outside of the string, to flow upwardly through the annulus **30** about the string to the upper end of the well. At the upper end of the well, the returning fluid received from annulus **30** is confined within a structure **31**, and is discharged from that structure through a line represented at **32** to a collection sump **33** from which pump **28** takes suction through a line **34** for recirculation of the fluid to the well. Before recirculation of the fluid, cuttings and other unwanted materials may be separated out of the fluid by a screen, filter or other separation system represented diagrammatically at **35**.

Pump **28** is preferably of the positive displacement type, typically including one or more piston and cylinder mechanisms represented at **36** in FIG. **1**, and with the pump being driven by a motor **37** at a rate which can be varied by a control represented at **38**.

Referring now to FIG. **2**, the instrument or tool section **27** of the drill string has a rigid tubular body **39** centered about axis **18** of the string and having its upper end threadedly connected at **40** to the next upper section **19** of the string and having its lower end threadedly connected at **41** to the lowermost section **24** of the string which contains and carries the mud motor. The drilling fluid flows downwardly from a passage **42** formed in the string above instrument section **27** into an axial passage **43** formed in body **39**, and from the lower end of passage **43** flows into a passage **44** in bottom section **24** to drive motor **25** and then be discharged through a passage represented at **45** to the bit.

The active elements of instrument section **27** of the string are preferably contained within cavities formed in the relatively thick sidewall of body **39** of section **27**, in order to isolate most of these elements from contact with the inherently abrasive drilling fluid or mud flowing downwardly through passage **43** in body **39**. These active elements of section **27** may include an instrument **46** adapted to sense a condition or conditions in the well, battery pack **47** for energizing the instrument and other related parts, an electronic circuit **48**, and an electrically operated device **49** for actuating a valve **50** between open and closed positions. Valve **50** acts to control flow of the circulating fluid from passage **43** through a passage **51** in the side wall of body **39** to the exterior of that body. The valve **50** may be a gate valve which is actuable vertically between the closed condition of FIG. **2** in which it blocks flow of fluid laterally from passage **43** and the open position of FIG. **3** in which fluid is permitted to bypass laterally through passage **51** to the annulus about body **39** without flow through motor **25** and the bit. The actuator **49** for valve **50** may be a solenoid which opens the valve when energized and permits closure of the valve by a spring represented at **52** when the solenoid is deenergized.

Instrument **46** may be capable of responding to any condition in the well which is of significance to the drilling operation and about which information is to be conveyed to the surface of the earth. For example, the instrument may be a unit such as those shown in U.S. Pat. Nos. 3,791,043 issued Feb. 12, 1974 entitled "Indicating Instruments", Michael King Russell, Inventor, and 3,862,499 issued Jan. 28, 1975 entitled "Well Surveying Apparatus", Carroll E. Isham et al, Inventors, for sensing the inclination of the lower portion of a drill string and the direction of that inclination. More specifically, instrument **46** may contain two or three gravity sensors **53** adapted to respond to or sense different components of inclination of the instrument with respect to three different mutually perpendicular axes fixed relative to the instrument body, and two or three magnetic sensors **54** adapted to respond to different mutually perpendicular components of the earth's magnetic field for determining the compass direction in which the instrument is inclined. The signals developed by sensors **53** and **54** are delivered to electronic circuit **48**, which delivers them in an appropriately multiplexed sequential fashion to solenoid **49** to open and close valve **50** in correspondence with the sensed values. The multiplexed signals delivered by circuit **48** to solenoid **49** open and close valve **50** in a predetermined pattern representing in a known coded fashion the values sensed by elements **53** and **54**.

Each time the valve **50** is opened, the bypassing of fluid through passage **51** from the interior of body **39** to its exterior results in an increased flow of circulating fluid downwardly through the drill string from its upper end. The setting of motor **37** which drives mud pump **28** is not changed while signals are being transmitted to the earth through the circulating fluid string, with the result that the opening of valve **50** reduces the resistance to flow of the said downwardly through the string and permits pump **28** to operate at an increased rate by virtue of the reduction in resistance to flow. Conversely, when valve **50** is closed, the increased resistance to downward flow of the fluid through the drill string causes pump **28** and its driving motor **37** to operate at a reduced speed with reduced downward flow of the fluid.

To sense and respond to these changes in fluid flow rate, I provide at the upper end of the string a flow sensor assembly **55**, which may typically include an annular housing **56** disposed about an upper portion of the drill string above rotary table **21** and containing a sensor proper represented diagrammatically at **57** in FIG. **4**. In that figure, the sensor **57** is assumed to be of an optical type, positioned at the outside of a transparent window **58** connected into the side wall of an upper section **19** of the drill string in sealed relation. Unit **57** illuminates the interior of the drill string and the circulating fluid flowing downwardly therethrough, and responds visually to the rate of flow of that fluid to function as a flow meter producing an electrical output signal in lines **59** representing the rate of flow of the fluid downwardly through the drill string. This flow rate signal in lines **59** is delivered to a readout unit **60** which is located on or near the rig at the surface of the earth, and which contains electronic circuitry **61** acting to decode the signals transmitted by variations in fluid flow rate from the downhole location, and acting to electronically process that data in a manner deriving desired output information therefrom for actuating indicators **62** and **63** to display that information. One of these indicators may be a dial device indicating in degrees the inclination of downhole instrument **46** and the lower portion of the drill string relative to the vertical, while the second indicator **63** may be a dial device whose pointer represents in degrees the azimuth or compass direction of that inclination and/or the number of degrees through which section **27** of the drill string is turned about its longitudinal axis from a predetermined position in which a certain side of body **39** or an index marking thereon is at the "high side" of an inclined hole.

During the drilling of a well by the apparatus shown in FIGS. **1** to **4**, it is contemplated that in most instances the information sensed at the bottom of the well will not be conveyed to the surface of the earth continuously, but will be transmitted only intermittently at such intervals as are required to properly monitor the drilling operation. Appropriate means may be provided for initiating such intermittent operation of the downhole sensing equipment and its controlled valve **50**. For example, if desired, the electronic circuitry **48** may include a timing circuit acting to energize instrument **46** and the related circuitry and actuate solenoid **49** and valve **50** through a cycle of information transmitting operation at predetermined timed intervals. Alternatively, unit **27** may contain an element **64** which is capable of responding to a signal transmitted from the surface of the earth to the downhole location to initiate a cycle of operation of the sensing and signal transmitting equipment. For example, element **64** may be a pressure-responsive switch connected into the side wall **39** of passage **43** in section **27**, and adapted to respond to a predetermined increase or other change in fluid pressure in passage **43** to commence actuation of the sensing and signal transmitting equipment through a cycle of operation. Desirably, switch **64** responds to a pressure considerably in excess of the normal pressure maintained in passage **43** by the mud pump **28**, and acts when the pressure is momentarily increased to that value and then reduced to the normal operating pressure to commence the cycle of operation of sensors **53** and **54**, circuitry **48**, solenoid **49** and valve **50**.

To recapitulate briefly the manner in which a well is drilled utilizing the equipment of FIGS. **1** through **4**, during most of the drilling operation valve **50** is in the condition represented in FIG. **2**, and the circulating fluid delivered by pump **28** to the upper end of the drill string flows downwardly through the string and through passage **43** to mud motor **25**, which is then driven by the fluid to turn bit **23**, with the fluid charging from the bit and flowing upwardly through annulus **30** for return to pump **28** and recirculation thereby. During such drilling, the pressure applied by the circulating fluid to pressure switch **64** is not great enough to activate the sensing circuitry of section **27**, and therefore valve **50** is held in closed condition. When it is desired to utilize the instrument section **27** for sensing inclination and the direction of that inclination (or another condition of the well), the operator first actuates control **38** of motor **37** to increase the rate of operation of the pump **28** and thereby increase the pressure at switch **64** to a predetermined value to which that switch responds, after which the speed of the pump is reduced to the original drilling condition. Electronic circuitry **48** responds to this momentary increase and then decrease in pressure in passage **43** to energize the circuitry associated with sensors **53** and **54**, and cause delivery of a cycle of multiplexed signals from unit **48** to solenoid **49** acting to open and close valve **50** in a coded pattern representing gravity and direction components sensed by elements **53** and **54**. Each time valve **50** opens, it bypasses some of the fluid from within passage **48** to reduce the resistance to downward flow of fluid through the drill string above the location of passage **51** and thereby permit pump **28** to operate at an increased speed. The resultant increase in the rate of flow downwardly through the portion of the drill string which is within flow rate sensor or meter assembly **55** is sensed by element **57** of FIG. **4**, which delivers a corresponding signal to readout unit **60**. Circuitry **61** of that unit decodes and processes an entire series of such signals received from the flow sensor and actuates the pointers of dial devices **62** and **63** to indicate to an operator the inclination of the lower portion of the well and the direction of that inclination. After a cycle of such operation of the signal transmitting equipment, downhole circuitry **48** automatically returns to its initial condition in which sensors **53** and **54** are ineffective to control valve **50**, and that valve is maintained in closed condition until the next successive operating cycle.

FIG. **5** represents schematically a variational arrangement in which a sensor element **57*a*** utilized in lieu of optical sensor **57** of FIG. **4** is adapted to respond electronically or magnetically to changes in the rate of downward flow of drilling fluid through drill string **19*a***. When such an electronic or magnetic sensor is employed, the drilling fluid is compounded to include particles of an appropriate electrically conductive or magnetic substance capable of producing the desired flow meter output from sensor **57*a***.

FIG. **6** shows another variational arrangement in which there is substituted for the optical sensor of FIG. **4** or the electronic or magnetic sensor of FIG. **5** a mechanical sensor **57*b***, including a paddle wheel element **65** which is exposed to the flow of circulating fluid downwardly through the upper portion **19*b*** of the drill string above the rotary table, and which turns about an axis **66** at a rate corresponding to the rate of downward flow of the fluid and acts to drive a unit **67** which develops an electrical output corresponding to the rate of fluid flow, to be delivered to readout unit **60** for controlling the operation of indicators **62** and **63**.

FIG. **7** shows another arrangement for sensing variations in the rate of flow of the fluid downwardly through the drill string, to be utilized in lieu of the sensors of FIGS. **4**, **5** and **6**. In FIG. **7**, the rate of flow of the fluid is sensed by responding to variations in the rate at which pump **28** is driven by motor **37**. As indicated previously, when valve **50** at the downhole location is opened, the rate of operation of pump **28** by motor **37** automatically increases. In FIG. **7**, this increase in speed of the pump is sensed by an element **68**, which may be an acoustical sensor responding to the increase in frequency of the reciprocations of the pistons of pump **28**, and acting to deliver electrical signals representing those pump speed variations through a line **69** to readout unit **60*c***, containing an electronic circuit **61*c*** which decodes and processes the information from sensor **68** and actuates indicators **62**c and **63**c in correspondence therewith to represent the information sensed at the downhole location.

FIG. **8** shows a variational form of downhole instrument section **27**d which can be substituted for section **27** of FIGS. **1** to **3** to vary the rate of downward flow of fluid through the interior of the drill string in a different manner. In lieu of valve **50** of FIGS. **2** and **3**, the unit **27**d of FIG. **8** includes a valve **50**d which is actuable upwardly and downwardly by solenoid **49**d between open and closed positions relative to an annular seat **51**b formed in the interior of the body **39**d of section **27**d. In this arrangment, there is no bypassing of fluid from the interior to the exterior of body **39**d, but instead valve **50**d acts when momentarily closed to temporarily interrupt downward flow of drilling fluid through the drill string to the mud motor and bit. Operation of the valve is under the control of an instrument **46**d which may be the same as instrument **46** of FIGS. **2** and **3** to sense inclination or azimuth or any other desired downhole condition, with batteries **47**d energizing the instrument and an electronic circuit **48**d which delivers coded information to solenoid **49**d representing the information sensed by instrument **46**d, to actuate valve **50**d in correspondence with that information. As will be understood, each time the valve **50**d is closed, the rate of downward flow of fluid is reduced, and that change in rate of flow can be sensed by any of the flow meter units of FIGS. **4**, **5**, **6** or **7**, or their equivalent, to actuate the readout unit in correspondence with and in a manner representing the information sensed deep within the well.

In addition to the various arrangements specifically described above, it is contemplated as previously mentioned that the telemetering apparatus of the present invention may be utilized in a drilling rig in which the entire drill string is turned by the rotary table **21** to rotate bit **23** in the well. In that event, the bit is rigidly carried by the lower end of the string, and mud motor **25** is omitted from the apparatus.

While certain specific embodiments of the present invention have been disclosed as typical, the invention is of course not limited to these particular forms, but rather is applicable broadly to all such variations as fall within the scope of the appended claims.

What is claimed is:

1. Apparatus for conveying information from a downhole location within a well in which circulating fluid flows in a line extending from the well surface downwardly to said location and then returns to the well surface, comprising:

means for varying the rate of flow of said circulating fluid in said line by controllably operating valving at said downhole location and in correspondence with said information to be conveyed to the surface of the earth;

means for sensing variations in the rate of flow of said fluid near the well surface as an indication of said information;

and motor driven pump means operating to pump the fluid to flow in said line, the motor set to cause the rate of flow from the pump to increase and decrease in correspondence to opening and closing of said valving;

said flow rate sensing means including means for acoustically sensing variations in the speed of operation of the pump means, and including readout means responsive to the sensing means and operable to produce an output representative of or dependent upon the downhole information.

2. Apparatus as recited in claim **1**, in which said sensing means includes a flow meter responsive to variations in the rate of flow of circulating fluid into the upper end of said well and downwardly therethrough.

3. Apparatus as recited in claim **1** including readout means responsive to said flow rate sensing means to produce an output representative of or dependent upon said information.

4. Apparatus as recited in claim **1**, including display means at the well surface responsive to said flow rate sensing means to produce a visual display representative of or dependent upon said downhole information.

5. Apparatus for conveying information from a downhole location within a well in which circulating fluid flows in a line extending from the well surface downwardly to said location and then returns to the well surface, comprising:

means for varying the rate of flow of said circulating fluid in said line by controllably operating valving at said downhole location and in correspondence with said information to be conveyed to the surface of the earth;

means for sensing variations in the rate of flow of said fluid near the well surface as an indicator of said information;

and motor driven pump means operating to pump the fluid to flow in said line, the motor set to cause the rate of flow from the pump to increase and decrease in correspondence to opening and closing of said valving said flow rate sensing means including means for acoustically sensing variations in the operating speed of said pump means as an indication of said variations in the rate of fluid flow, there being readout means responsive to said acoustic sensing means and operable to produce an output representative of or dependent upon said downhole information.

6. Apparatus as recited in claim **1**, in which said valving includes a passage in the string operable to bypass circulating fluid from the interior of the side string in the well to its exterior, and a valve stopper to open and close said passage, and means for actuating said stopper in correspondence with said information to vary the fluid flow through said valving in a relation altering the overall rate of fluid flow through the well.

7. Apparatus as recited in claim **1**, in which said valving includes a passage in the string to pass fluid flow downwardly through the lowermost extent of the pipe string in the well, and a valve stopper operable to open and close said passage to vary the rate of fluid flow through the string to the lower end thereof.

8. Apparatus as recited in claim **1**, including an instrument within the well near said downhole location operable to sense variations in a downhole condition and deliver an output representative of said variations in said condition to said flow rate varying means as information to be conveyed to the surface of the earth.

9. Apparatus as recited in claim **1**, including an instrument received within the pipe string at said downhole location and which is responsive to the inclination of the well and the direction of that inclination and produces an output to said flow rate varying means representative of said inclination and direction and constituting said information to be conveyed to the surface of the earth, said sensing means including a flow meter near the surface of the earth responsive to variations in the rate of delivery of circulating fluid to the upper end of said pipe string for flow downwardly therethrough, said apparatus including readout means responsive to said flow rate sensing means to produce an output at the surface of the earth representative of or dependent upon said inclination and direction sensed by said instrument.

10. The method of transmitting information to the surface of the earth from a downhole location within a well pipe in which circulating fluid flows downwardly to said location and then back to the surface of the earth, comprising:

operating valving to vary the rate of flow of said circulating fluid at said downhole location in the well pipe in correspondence with said information; said rate of flow variations being correspondingly effected in substantially the entirety of the well pipe above said downhole location; and

sensing variations in the rate of flow of said fluid near the surface of the earth as an indication of said information,

said circulating fluid produced by pump means whose speed is effectively sensed, and including operating a motor driving the pump means to allow pump speed to vary as the valving varies said rate of flow of the fluid.

11. The method as recited in claim **10**, in which the rate of flow of said circulating fluid at said downhole location is varied by variably bypassing circulating fluid from the interior of the well pipe in the well to its exterior at said downhole location.

12. The method as recited in claim **10**, in which said well pipe carries a motor near its lower end driven by said circulating fluid to turn a bit for drilling the well, said rate of flow of circulating fluid at said downhole location being varied by variably bypassing a portion of the circulating fluid from the interior of the pipe upstream of said motor to the exterior of the pipe, the remainder of the fluid flowing to the motor.

13. The method as recited in claim **10**, including producing an output at the surface of the earth indicative of or dependent upon variations in the rate of flow of said fluid near the surface of the earth.

14. The method as recited in claim **10**, in which said last step of the claim includes sensing variations in the rate of flow of said fluid into the upper end of the pipe string in the well.

15. The method of transmitting information to the surface of the earth from a downhole location within a well pipe in which circulating fluid flows downwardly to said location and then back to the surface of the earth, comprising:

operating valving to vary the rate of flow of said circulating fluid at said downhole location in the well pipe in correspondence with said information; said rate of flow variations being correspondingly effected in substantially the entirety of the well pipe above said downhole location; and

sensing variations in the rate of flow of said fluid near the surface of the earth as an indication of said information, being delivered to the well pipe under pressure exerted by reciprocating pump means, said sensing of variations in the rate of flow of fluid near the surface of the earth being effected by sensing changes in the rate of reciprocation of said pump means, and including operating a motor driving said pump means to allow the speed of the pump means to increase and decrease as the valving decreasingly and increasingly restricts the fluid flow.

16. The method as recited in claim **15**, in which said circulating fluid is delivered to the upper end of a drill string in the well pump means, and in which there is a motor carried by the string near its lower end and driven by said circulating fluid to turn a bit for drilling the well, said varying of the rate of flow of said circulating fluid at said downhole location being effected by variably bypassing circulating fluid from within the drill string upstream of said motor to the exterior of the string, said sensing of variations in the rate of flow near the surface of the earth being effected by sensing changes in the rate of delivery of circulating fluid under pressure from said pump means to the drill string.

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